

# Integrated Ocean Observing System (IOOS) Data Integration Framework (DIF) Project

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***NOAA IOOS Program***  
***DIF Sr Systems Architect***

# Acknowledgements

## **NOAA Offices:**

- NWS/NDBC
- NOS/CO-OPS
- NOS/CSC
- OAR/PMEL
- NESDIS/NGDC
- NMFS/SWFSC
- NESDIS/NCDDC
- NESDIS/NODC
- NOS/CSDL
- OAR/AOML
- NOS/IOOS

## **External:**

- AOOS
- CenCOOS
- GCOOS
- MACOORA
- NANOOS
- NERACOOS
- PacIOOS
- SECOORA
- SCCOOS
- SURA

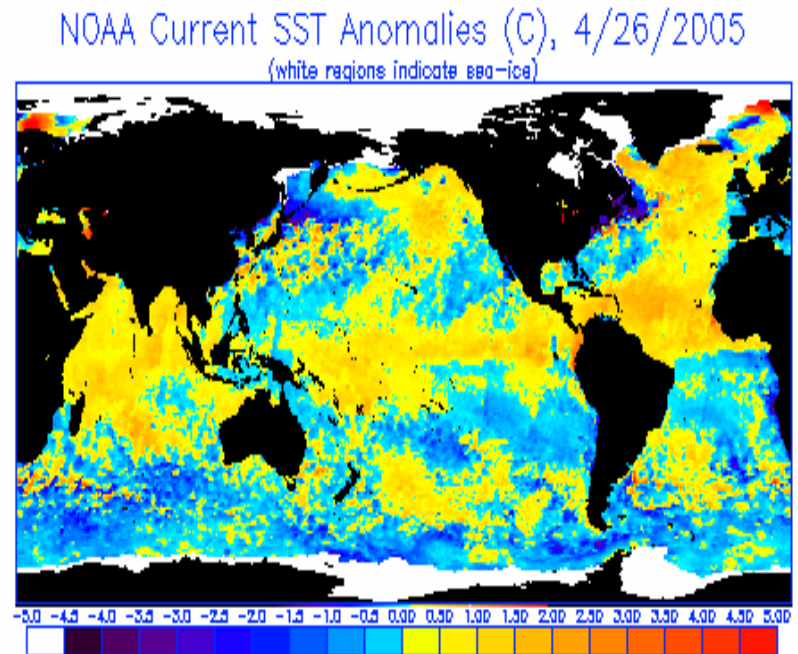
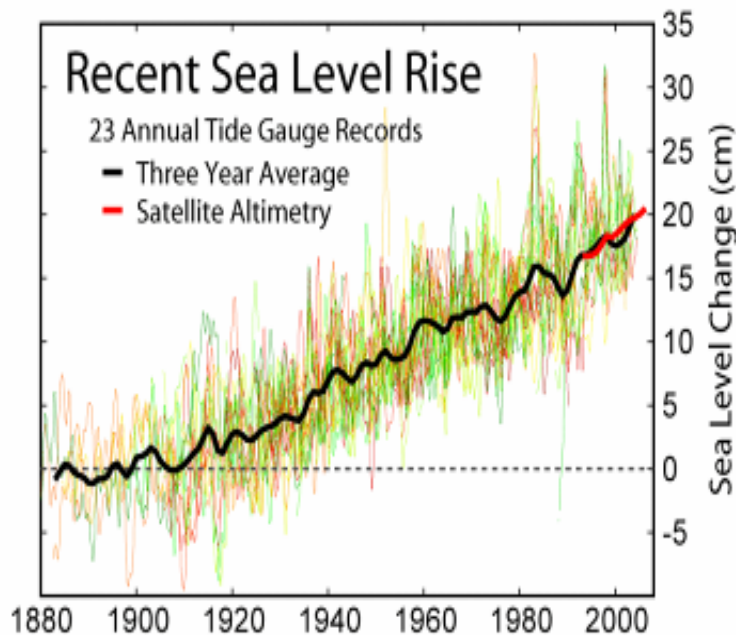
# Outline

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- **IOOS program overview**
- **Data Integration Framework (DIF) pilot**
- **Data Providers and Customers**
- **Recommended Web Services**
- **IOOS Practices**
- **Towards IOOS DMAC**

# Why Is Ocean Information So Important?

- Oceans are a primary driver of weather and climate
  - Potential to store 1000X more heat and 50X more carbon than the atmosphere (ocean acidification)
  - 85% of the rain and snow that provides water to our citizens come directly from the ocean.

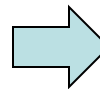
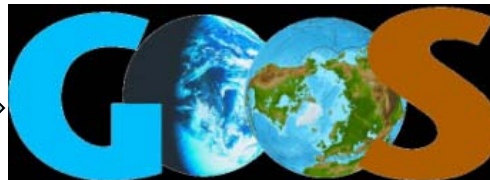
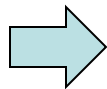


# US IOOS<sup>®</sup>

## US IOOS: a National Endeavor



## But Part of a Global Framework



IOOS

GOOS

GEOSS



# IOOS Regional Associations

## IOOS Regional Component

A network of 11 regional coastal ocean observing systems that meet national and regional needs for local ocean observations, data management, and modeling

1 national partnership providing sensor validation/verification

Meeting National missions through:

- Expanded observations and modeling capacity
- Connections to users and stakeholders
- Implementation of national data standards
- Sensor validation/verification
- Products transitioned to other regions and to National operations



1. Alaska Ocean Observing Systems (AOOS)
2. Caribbean Regional Association (CaRA)
3. Central and Northern California Coastal Ocean Observing System (CeNCOOS)
4. Gulf Coastal Ocean Observing System (GCOOS)
5. Great Lakes Observing System (GLOS)
6. Mid-Atlantic Coastal Ocean Observing System Regional Association (MACOORA)
7. Northwest Association of Networked Ocean Observing Systems (NANOOS)
8. Northeast Regional Association of Coastal Ocean Observing Systems (NERACOOS)
9. Pacific Islands Ocean Observing System (PacIOOS)
10. Southern California Coastal Ocean Observing System (SCCOOS)
11. Southeast Coastal Ocean Observing System Regional Association (SECOORA)
12. Alliance for Coastal Technologies (ACT) {Sensor V & V}





# Integrated Coastal and Ocean Observation System Act

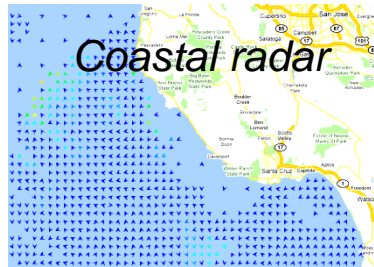
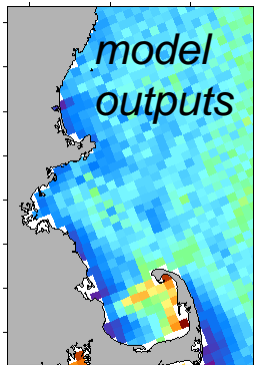
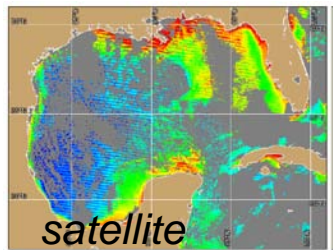
*Public Law No. 111-11*

- **Directs President to establish a National Integrated Coastal and Ocean Observation System**
  - Establishes Interagency Ocean Observation Committee
- **Interagency Ocean Observation Committee**
  - Establish System protocols and standards for IOOS Data Management
- **Identifies NOAA as Lead Federal Agency**
- **Defines “Regional Information Coordination Entities”**
- **Mandates Report to Congress every 2 years**
- **Establishes Civil Liability for NOAA**
- **Authorizes appropriation of “such sums as are necessary” through 2013**

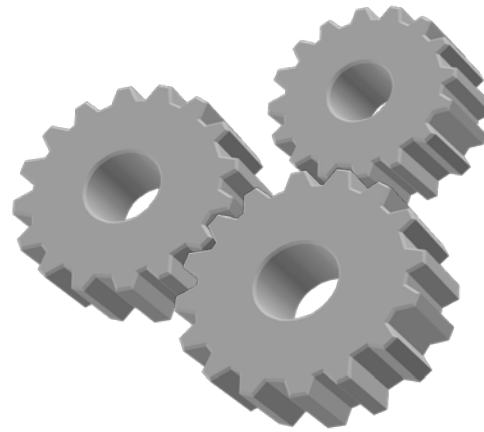
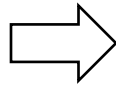


# NOAA IOOS Program Components

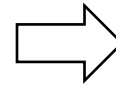
- Support for regional coastal observing systems
- Interagency coordination & standards adoption
- Improving interoperability and data management



Information



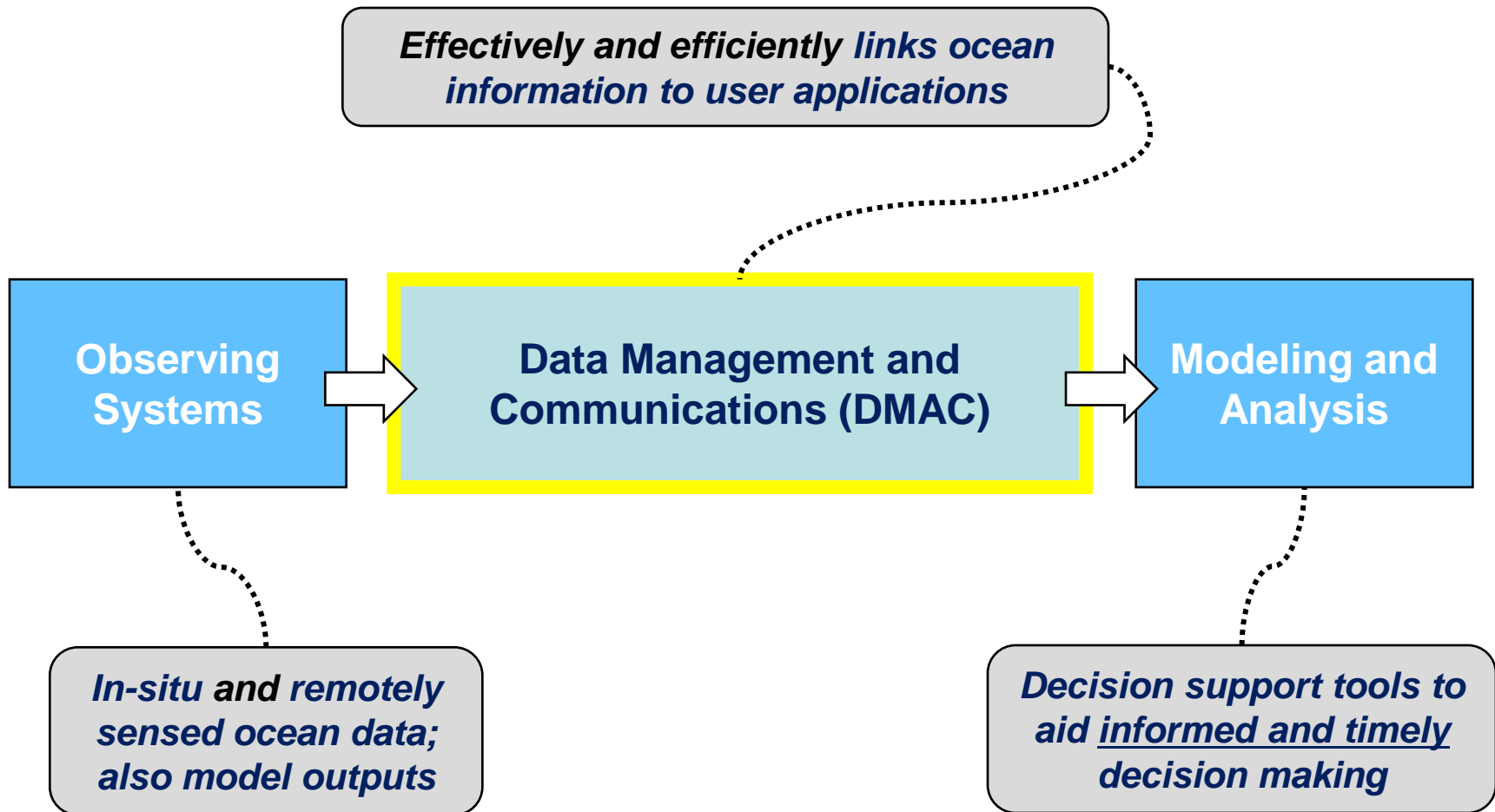
Data Management  
and Standards



Societal Benefit

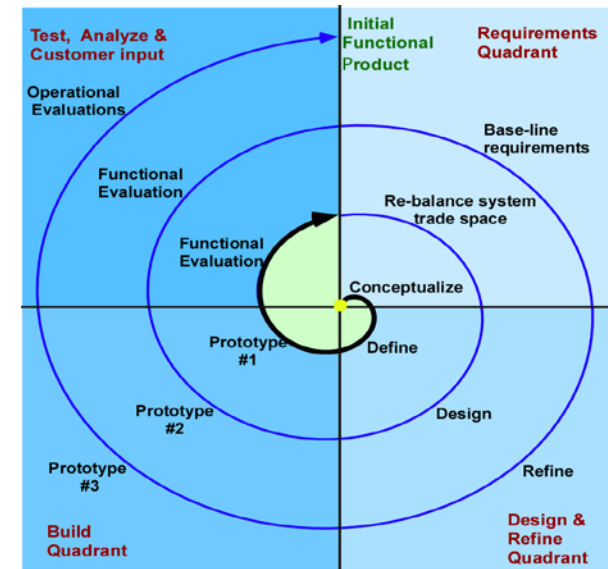


# IOOS Functional Areas



# Data Integration Framework (DIF)

- **Began as pilot project (2007-2010)**
  - First spiral of IOOS data management development
  - Evaluate in FY 2010
- **Limited scope for reduced risk**
  - 3 data providers and 4 customers
  - 7 core variables
    - Currents, Temperature, Salinity, Water Level, Winds, Waves, Ocean Color (chlorophyll)
- **See <http://ioos.gov/dif/> for:**
  - Links to data access services
  - SOS schema and software
  - Systems engineering documents



(Graphic by i3 Aerospace Technologies Pty Ltd  
– used with permission)

# Core Principles

- **Adopt open standards & practices**



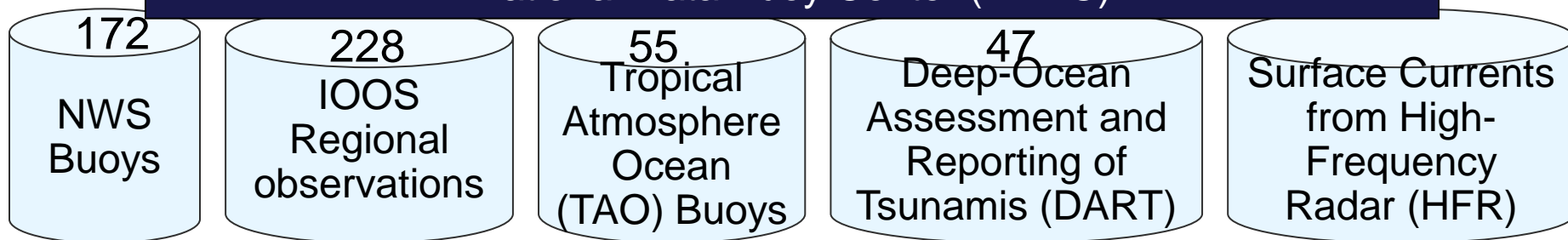
- **Federated, service-oriented architecture**
  - Data made accessible via OGC or DAP services
    - Not SOAP/WSDL services
  - Data stays with data providers
  - Service adapters for existing systems

# Primary DIF Partners

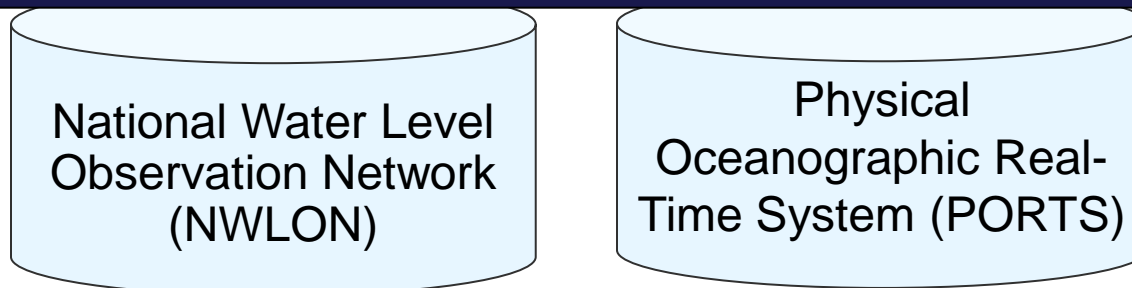
- **NOAA Data Providers**
  - NWS NDBC (National Data Buoy Center)
  - NOS CO-OPS (Ctr for Operational Oceanographic Prod & Svcs)
  - NESDIS CoastWatch
- **Customer Focus Areas**
  - HAB (Harmful Algal Bloom Forecast System)
  - IEA (Integrated Ecosystem Assessments)
  - CI (Coastal Inundation)
  - HI (Hurricane Intensification)
- **Regional associations**
  - As represented in web services working group

# IOOS DIF Project Data Providers

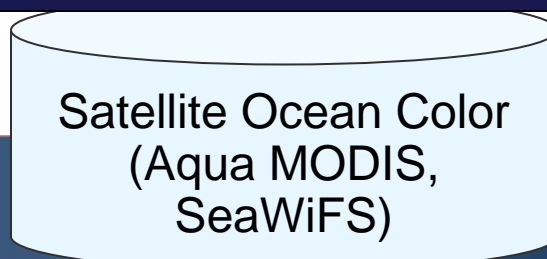
National Weather Service (NWS)  
National Data Buoy Center (NDBC)



National Ocean Service (NOS)  
Center for Operational Oceanographic Products and Services (CO-OPS)

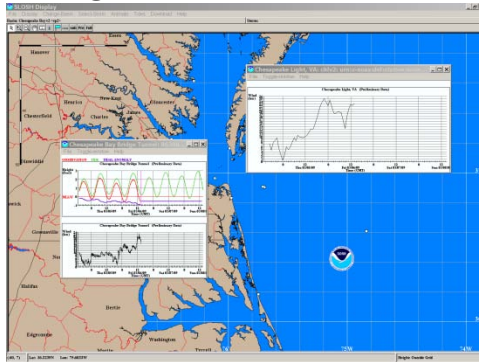


National Environmental Satellite, Data, and Information Service (NESDIS)  
CoastWatch

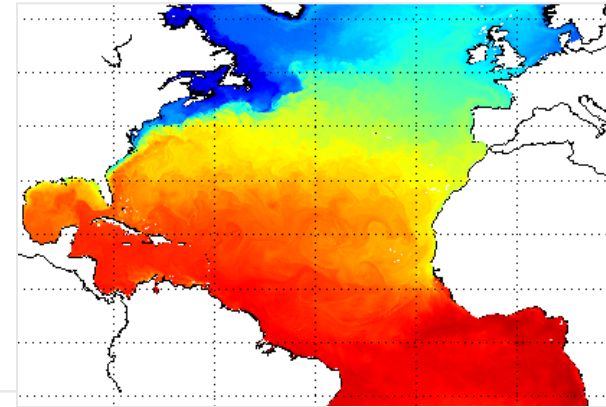


# IOOS DIF Customer Projects

Coastal Inundation: Sea, Lake and Overland Surge from Hurricanes (SLOSH) model

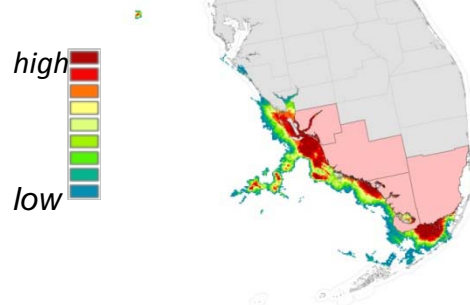


Hurricane Intensity: Real-Time Ocean Forecast System (RTOFS-Atlantic)

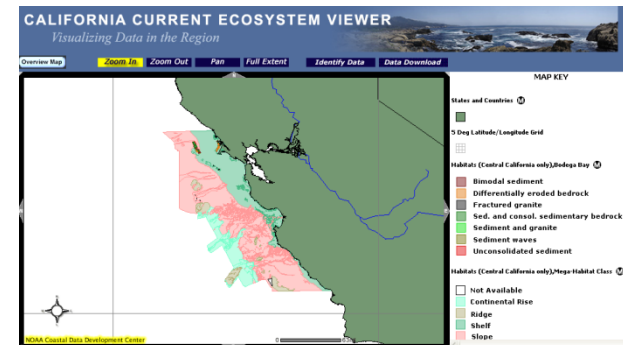


Harmful Algal Blooms: HAB Forecast System (HAB-FS)

HAB Intensification Potential



Integrated Ecosystem Assessments: Environmental Research Division Data Access Protocol (ERDDAP) application





# Additional IOOS DIF Data Providers *(in progress)*

NOAA /OAR/AOML

Atlantic Oceanographic and Meteorological Lab

Synthetic  
Temperature &  
Salinity Profiles

NOAA/NOS/CSDL

Coast Survey Development Lab

Model Forecast  
Currents

AOOS  
Alaska

NANOOS  
Northwest

CeNCOOS  
Cen & Nor CA

NERACOOS  
Northeast

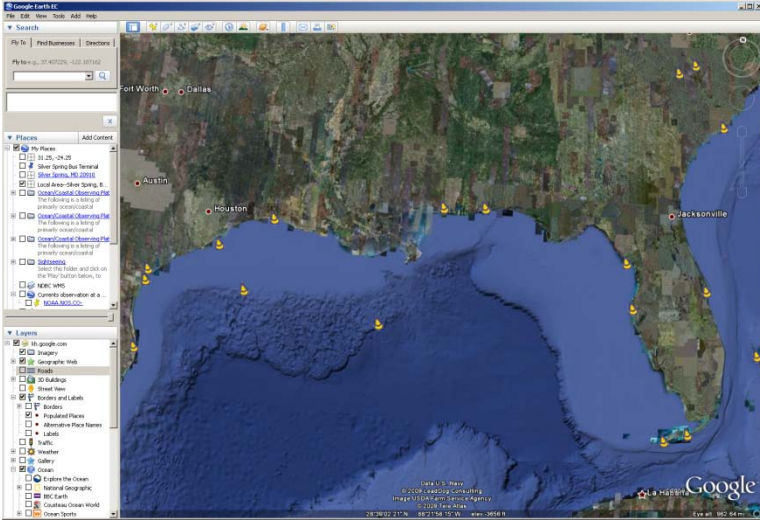
PacIOOS  
Hawaii

SCCOOS  
So Calif

GCOOS  
GoMex

SECOORA  
Southeast

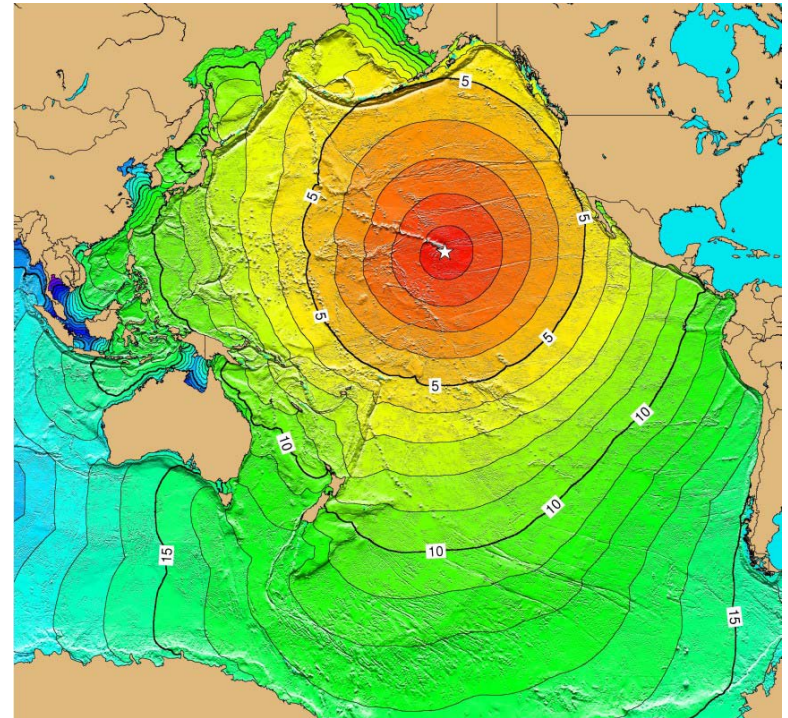
## Additional IOOS DIF Customers *(in progress)*



*Screenshot of Google Earth*

Google: Standardized access to observations for Google Oceans

## ➤ Exploring KML+JSON



Travel time map for November 29, 1975 tsunami in Hawaii (NOAA NGDC).

## Tsunami scientists: Prepackaged collections of event-specific observations from DART buoys

# Recommended Web Services and Data Encodings

## Data Type

## Web Service

## Encoding

In-situ data (buoys,  
piers, towed sensors)

OGC Sensor  
Observation Service  
(SOS)

XML based on OGC  
Observations and  
Measurements (O&M)

Gridded data (model  
outputs, satellite)

OpenDAP and/or  
OGC Web Coverage  
Service (WCS)

NetCDF using Climate  
and Forecast (CF)  
conventions

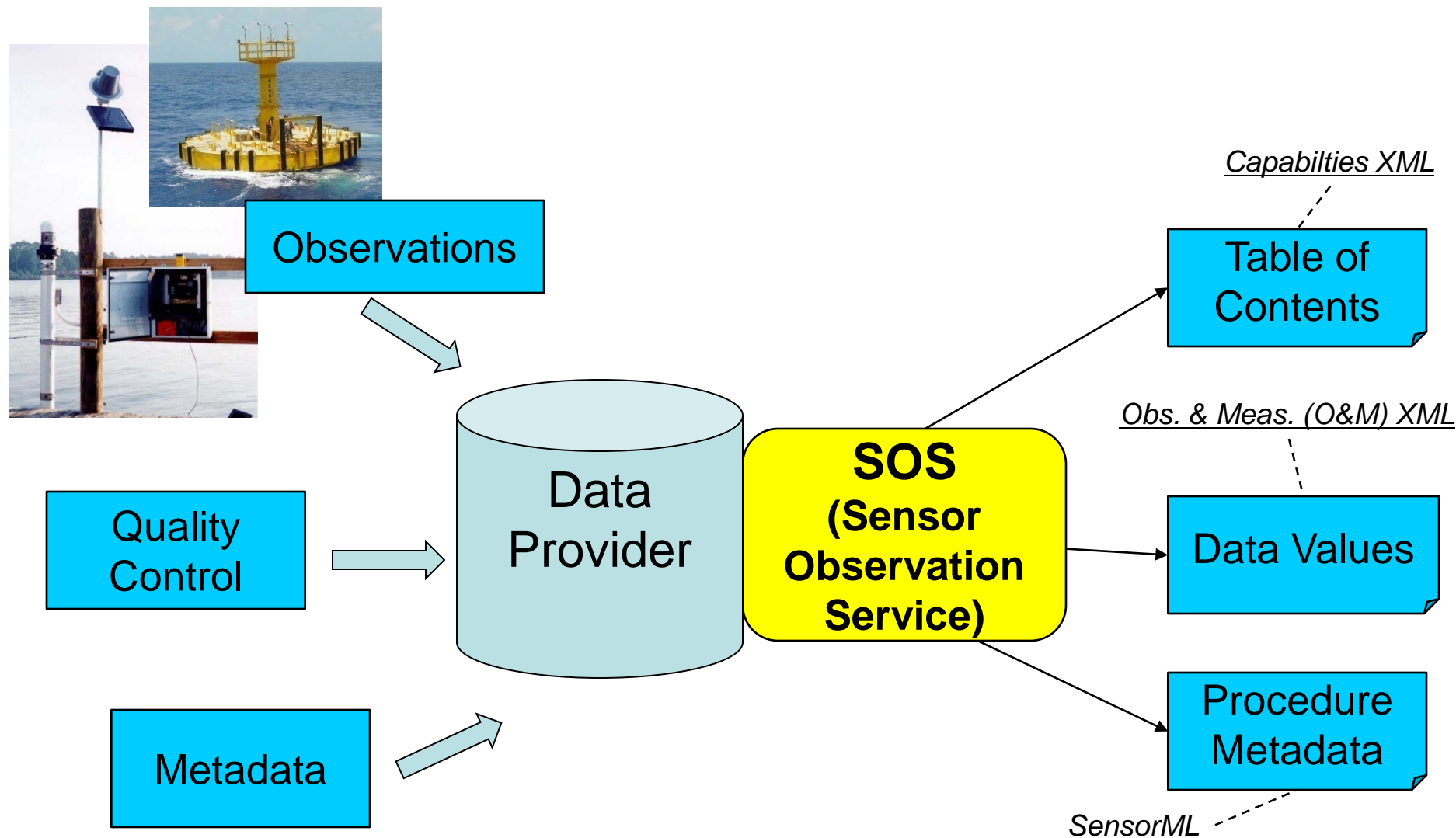
Images of data

OGC Web Map Service  
(WMS)

GeoTIFF, PNG etc.  
-possibly with  
standardized styles

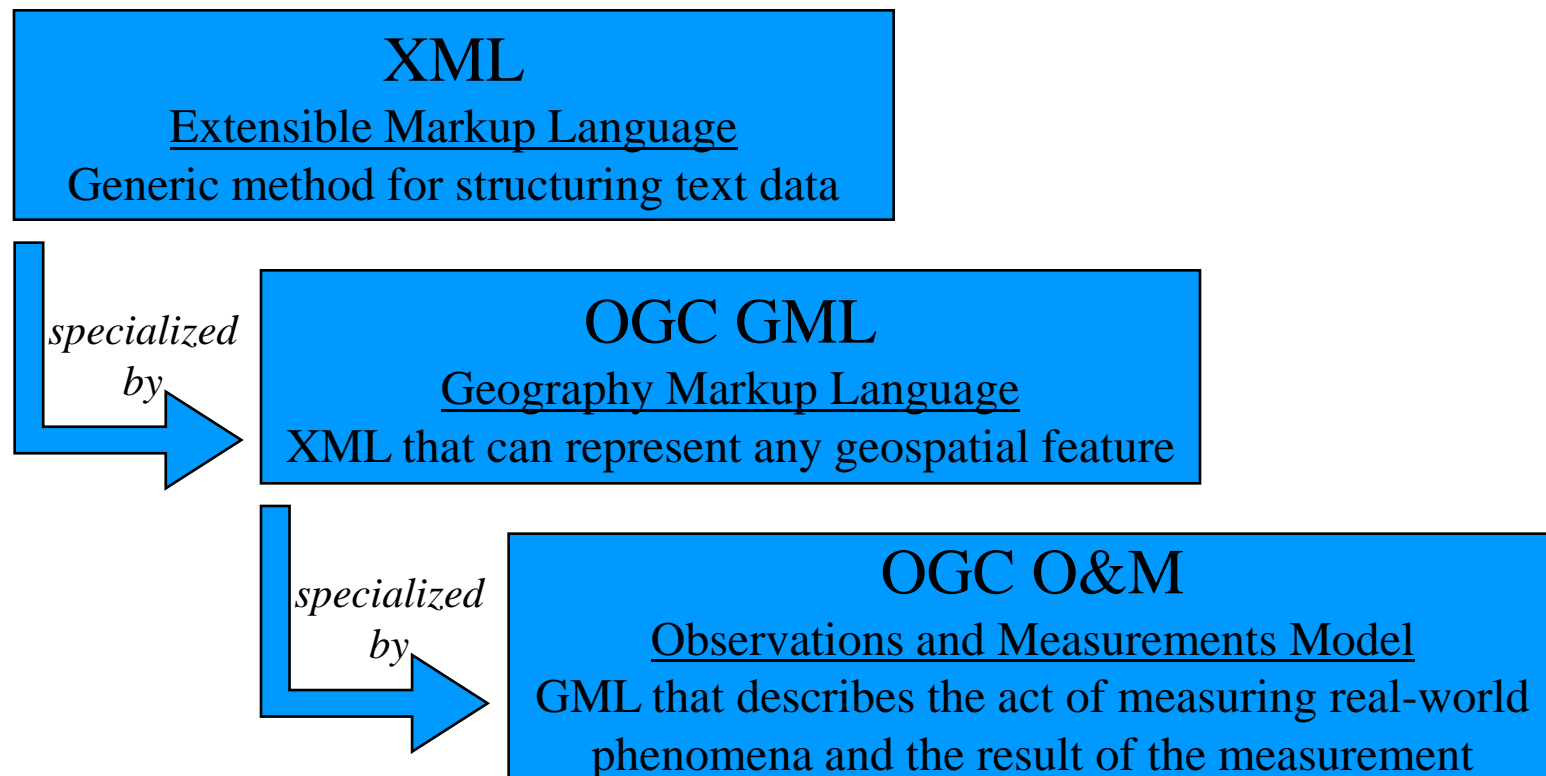
# SOS for *in situ* Observations

## Sensor Systems



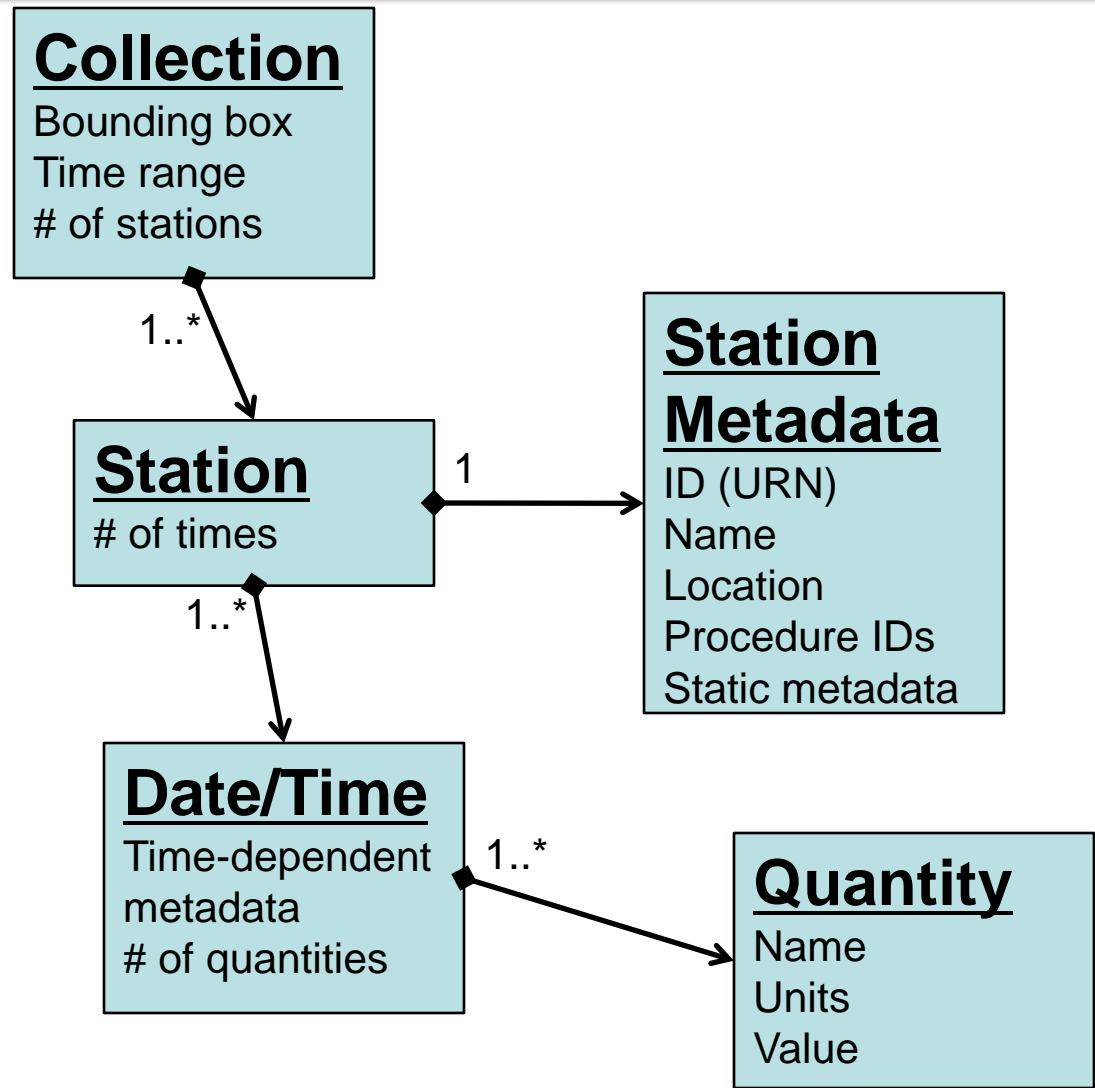
# SOS GetObservation Response

*XML Encoding of In-Situ Data*



# IOOS Data Model for Time Series at a Collection of Points

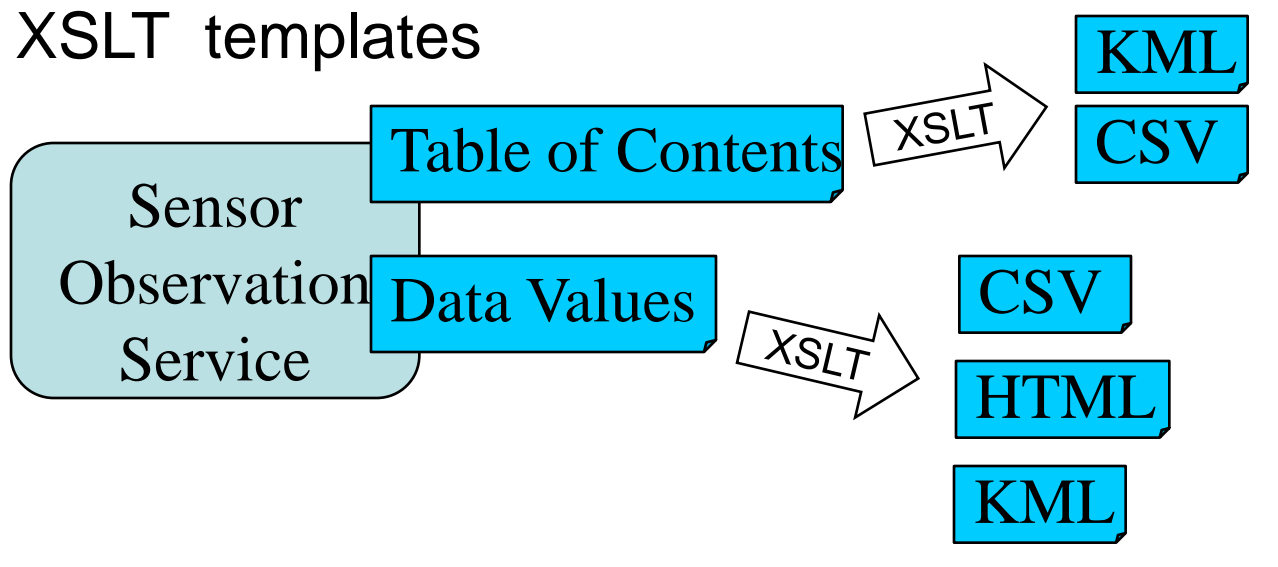
- **Collection**
  - Station 1
    - Time 1
      - quantity 1
      - quantity 2
    - Time 2
      - quantity 1
      - quantity 2
  - Station 2
    - Time 1
      - quantity 1
      - quantity 2
    - Time 2
      - quantity 1
      - quantity 2





# Format Conversion Tools

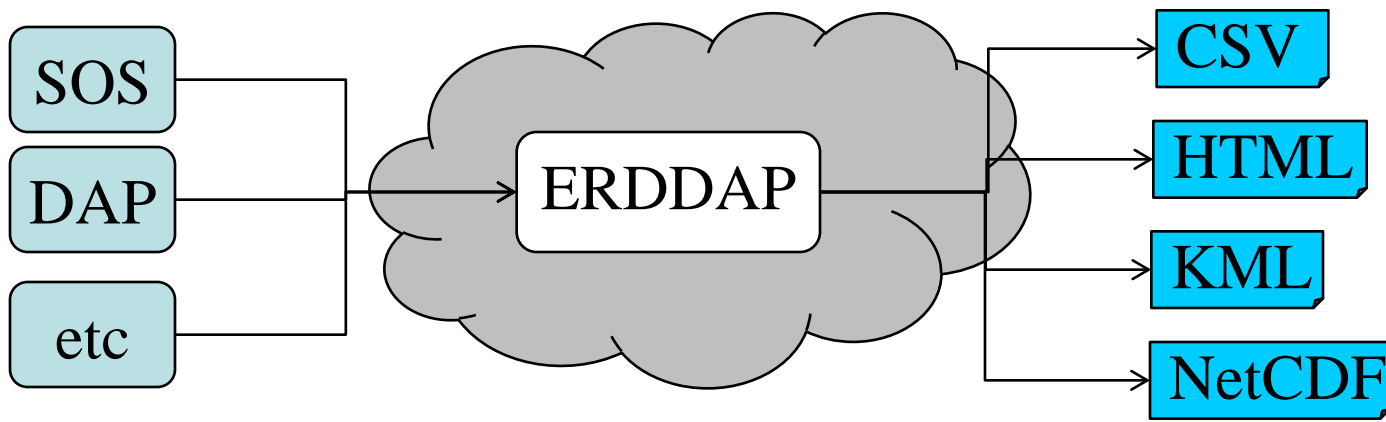
## XSLT templates



  
Spreadsheet

  
Browser

## Scalable translation service (NSF OOI/CI)

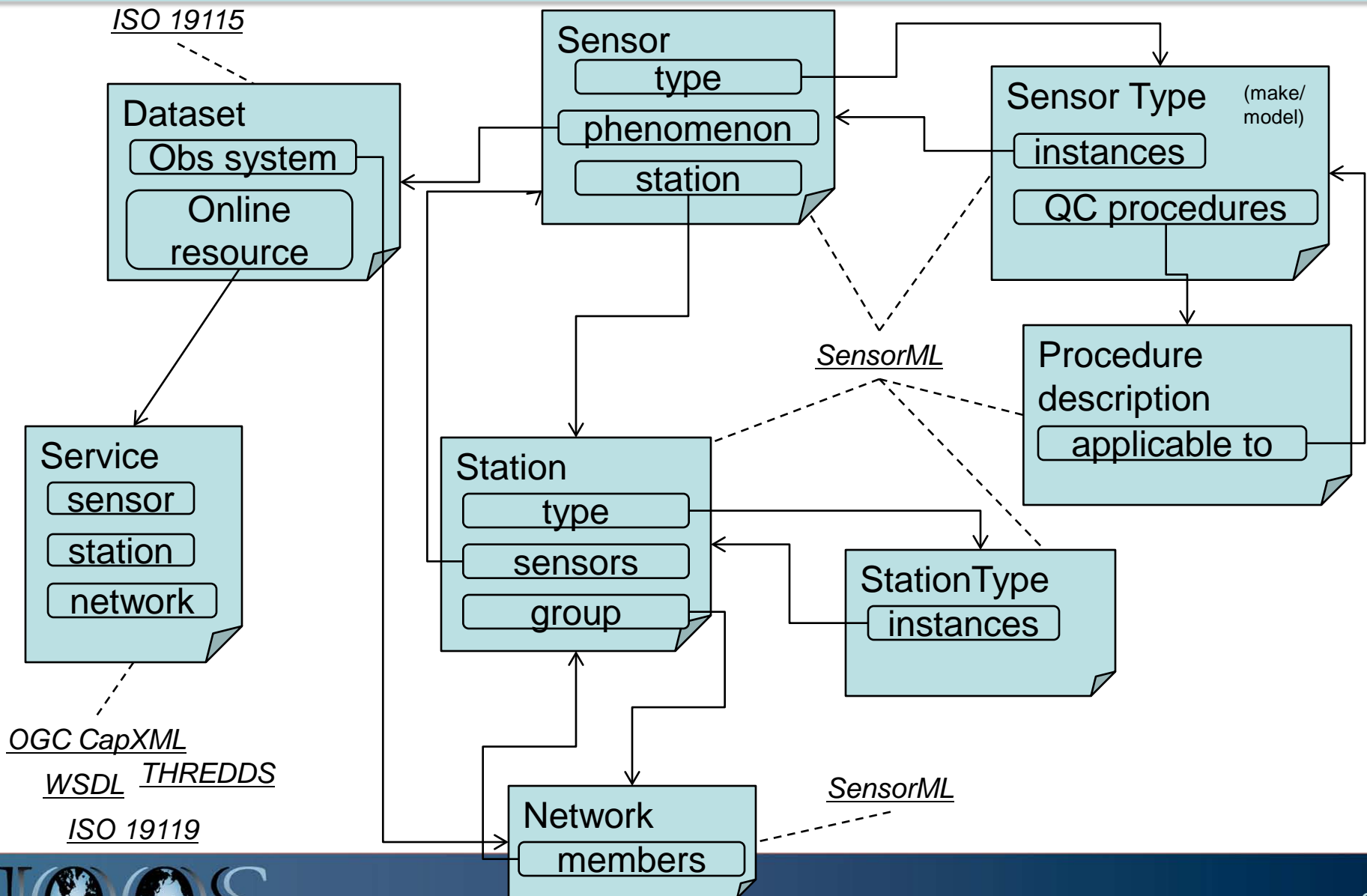


  
Virtual Globe

  
Science App

# IOOS Metadata Linkage Model

(Sensors, Stations, Networks, Datasets and Services)



# SOS Profile/Best Practices

- **SOS and O&M specs are fairly general**
  - Need community specialization/restriction
- **IOOS adopting, defining or researching practices:**
  - O&M schema
  - KML+JSON (Javascript Object Notation)
  - URIs for sensors, stations, networks, CRS, phenomenon names
  - HTTP GET request encoding
  - SensorML metadata
  - Observation Offerings

# IOOS Practice: Observation Offerings

- **Each station (buoy, fixed sensor package) is a separate Offering from the SOS**
  - Allows requests for data from 1 station at a time
- **Multi-station Offerings:**
  - “All stations” Offering
    - User specifies bounding box instead of station ID
  - Soon: program-specific or **event-specific Offerings**
    - E.g., “all Hurricane Katrina data”
  - Maybe: phenomenon-specific Offerings
    - E.g., “all temperature data”
- **Offering includes ID and English name**
  - gml:name = ID
  - gml:description = name
- **May replace multiple sensor IDs per offering with single station ID**

# IOOS Practice: Identifiers

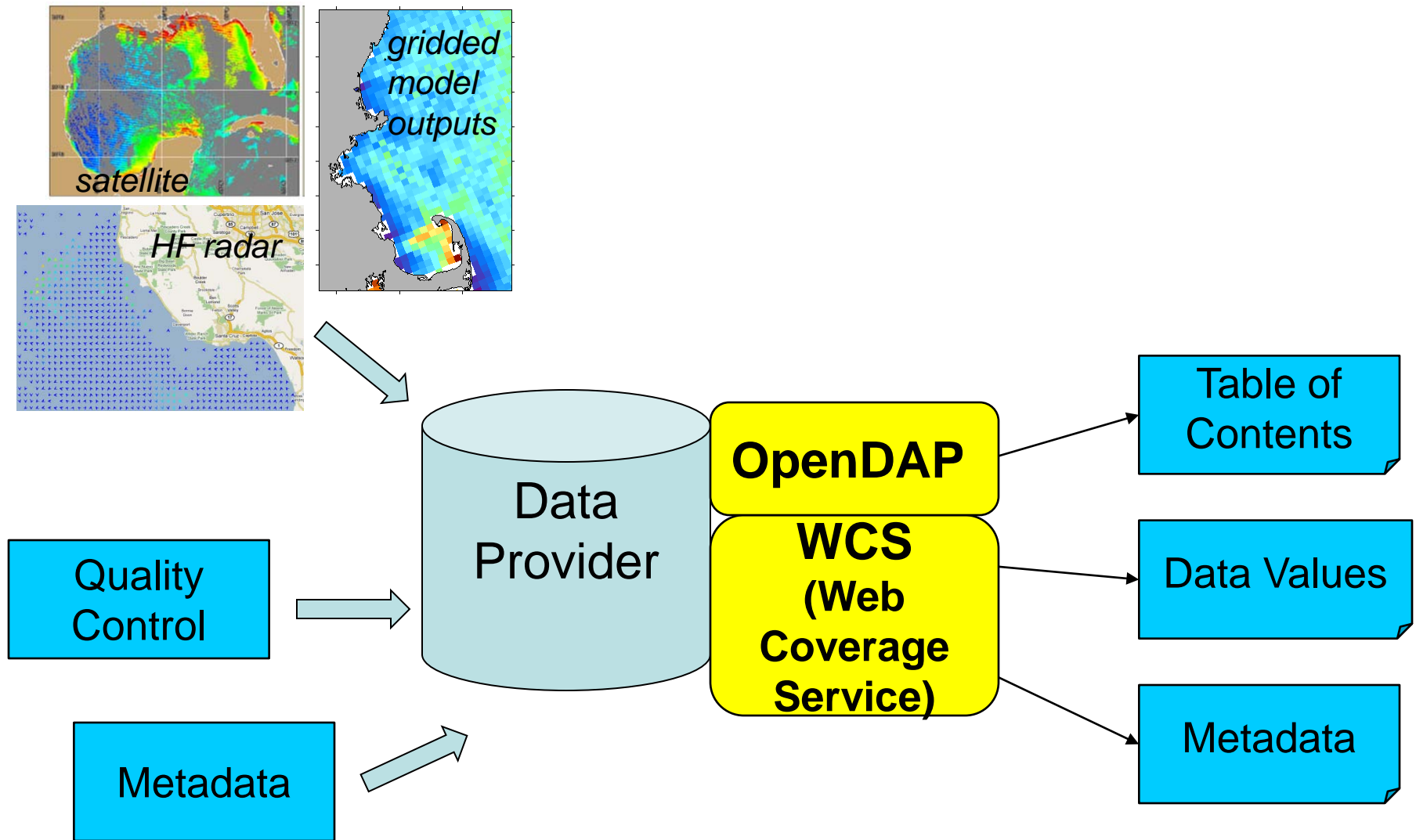
- **Using URNs for IDs of sensors, stations, networks (*URN = Uniform Resource Name*)**
- **Following “OGC Definition URN” practice**
- **Examples:**
  - urn:x-noaa:def:network:noaa.nws.ndbc::all
  - urn:x-noaa:def:station:noaa.nws.ndbc::21418
  - urn:x-noaa:def:sensor:noaa.nws.ndbc::21418:tsunameter0
- **Also using URNs for EPSG CRS identifiers**
- **Using URLs for phenomenon names**
  - Adopting MMI/CF URLs:  
[http://mmisw.org/ont/cf/parameter/sea\\_water\\_temperature](http://mmisw.org/ont/cf/parameter/sea_water_temperature)
  - Allow trailing component as abbreviation  
(sea\_water\_temperature)

# IOOS Practice: GetObservation Request

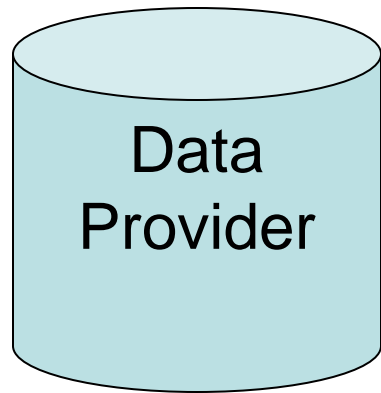
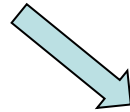
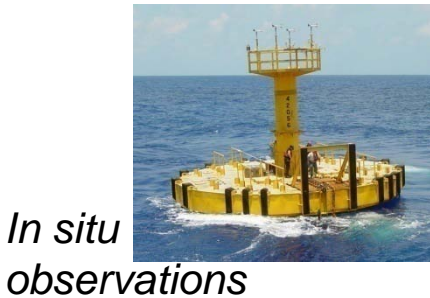
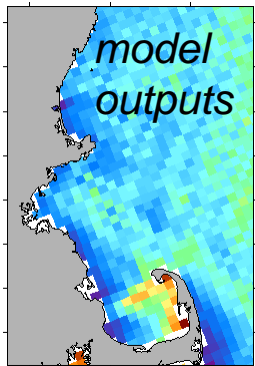
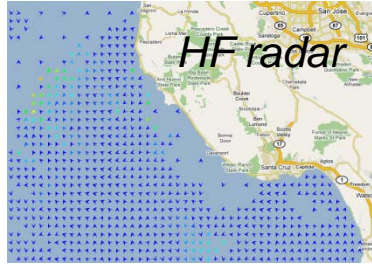
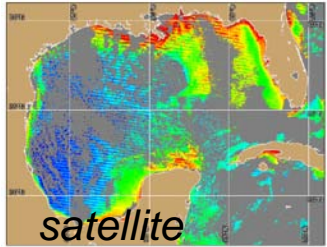
- **Supporting both HTTP POST requests and HTTP GET**
  - HTTP POST defined in spec, GET left out
  - Mostly following Oceans IE Best Practice for GET
    - For Bounding Box, using FOI that could be a BBOX or (in future) a named FOI:  
featureofinterest=BBOX:minlon,minlat,maxlon,maxlat



# WCS and/or OpenDAP for Gridded Data and Model Outputs



# WMS for Maps of Data



Capabilities XML

Table of  
Contents

Georeferenced  
Images

PNG, GIF, TIFF, JPEG

# Summary

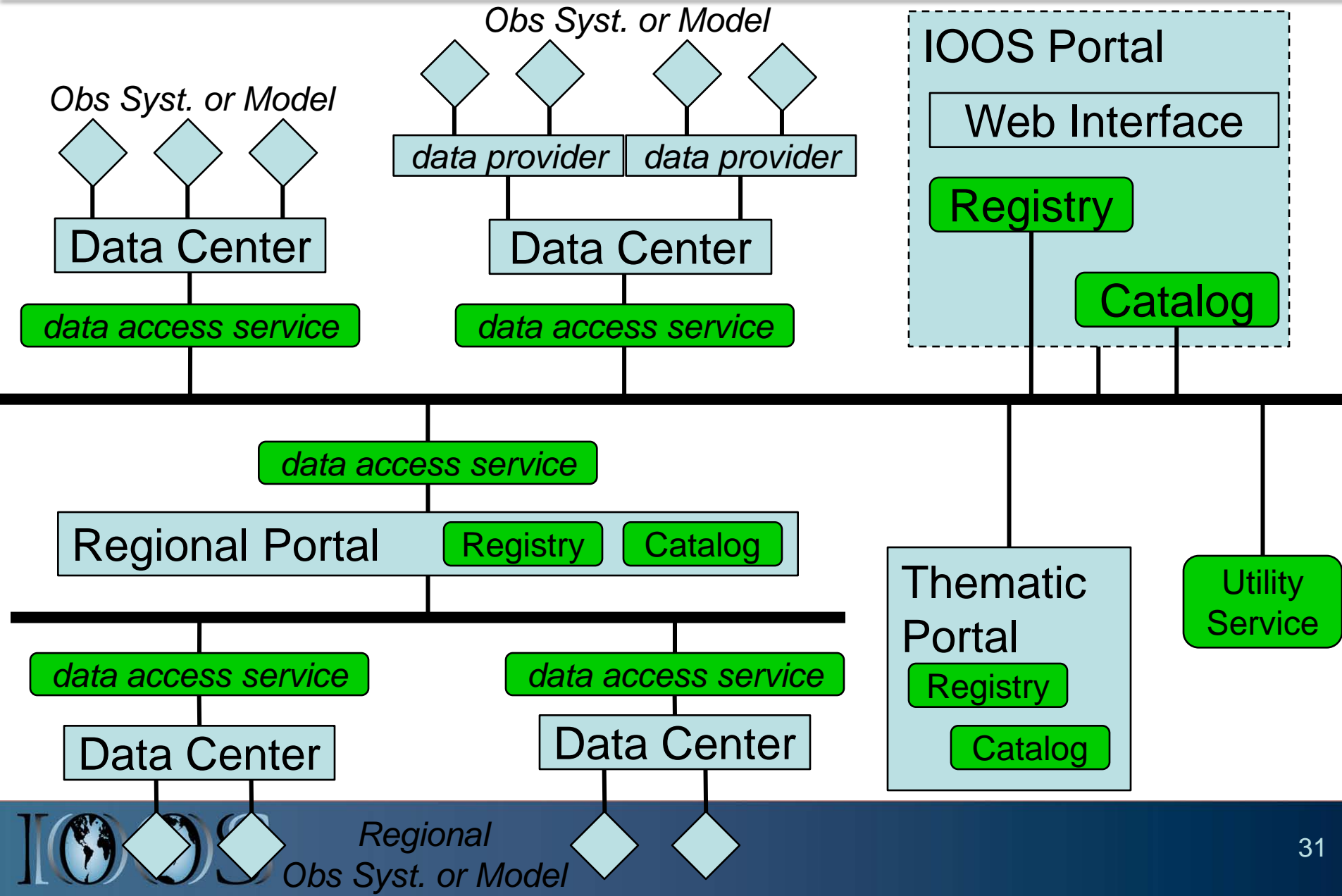
- **Standardized data access services implemented at operational data providers**

See <http://ioos.gov/dif/>

  - SOS: Point, Profile, Time Series, Collections
  - OpenDAP/WCS: Regular Grids
- **Implementing detailed metadata for sensors, platforms, systems**
- **SOS, WMS, WCS submitted as IOOS standards**
  - Need to document SOS Profile for ocean observations
- ***In planning: Expansion of DIF towards IOOS***
  - *Service types (Registry, Catalog, ...)*
  - *Data types (trajectory, unstructured grid, imagery)*
  - *Data providers, data customers*

# The Bigger Picture: Moving to National IOOS Data Management Capability

# Federated, Service-Oriented Architecture



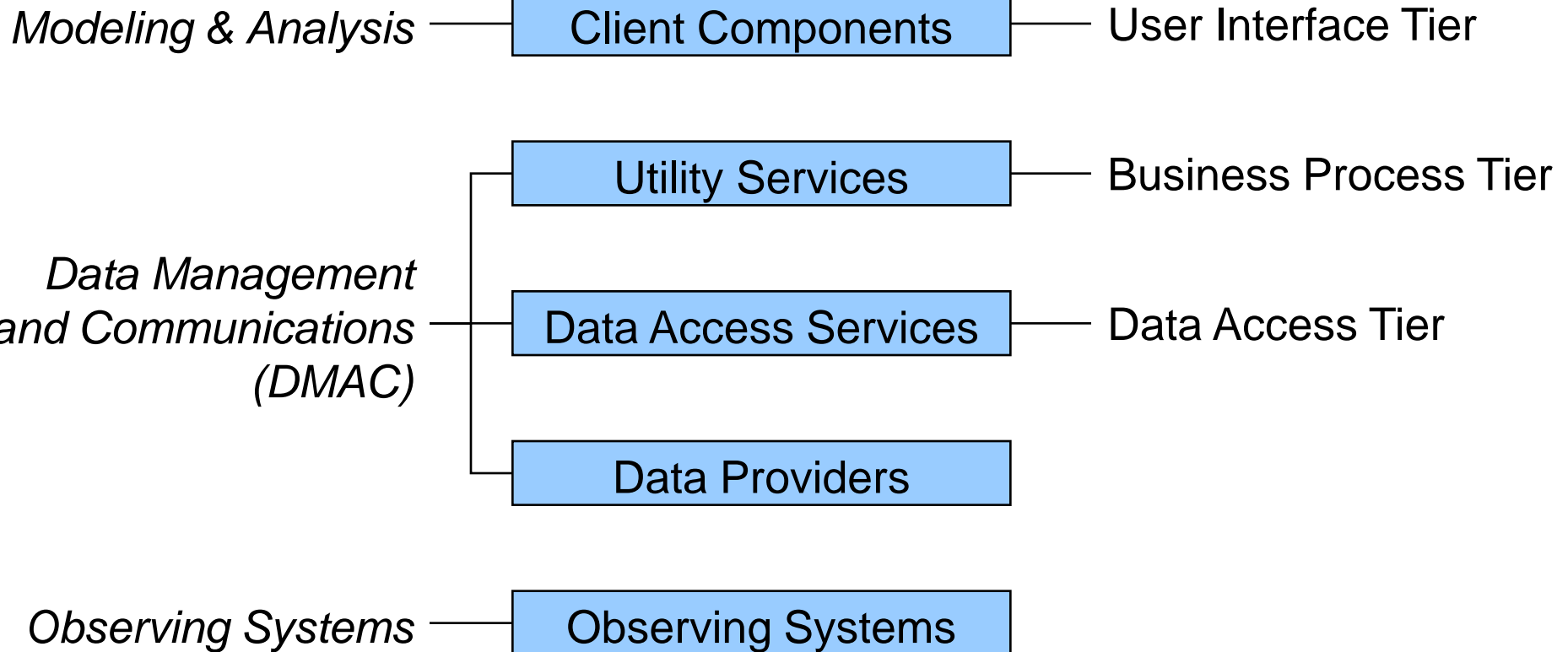
# IOOS Architectural Layers

and Relationship to IOOS “Subsystems” and ISO Model

## IOOS “Subsystems”

## ISO 3-Layer Model

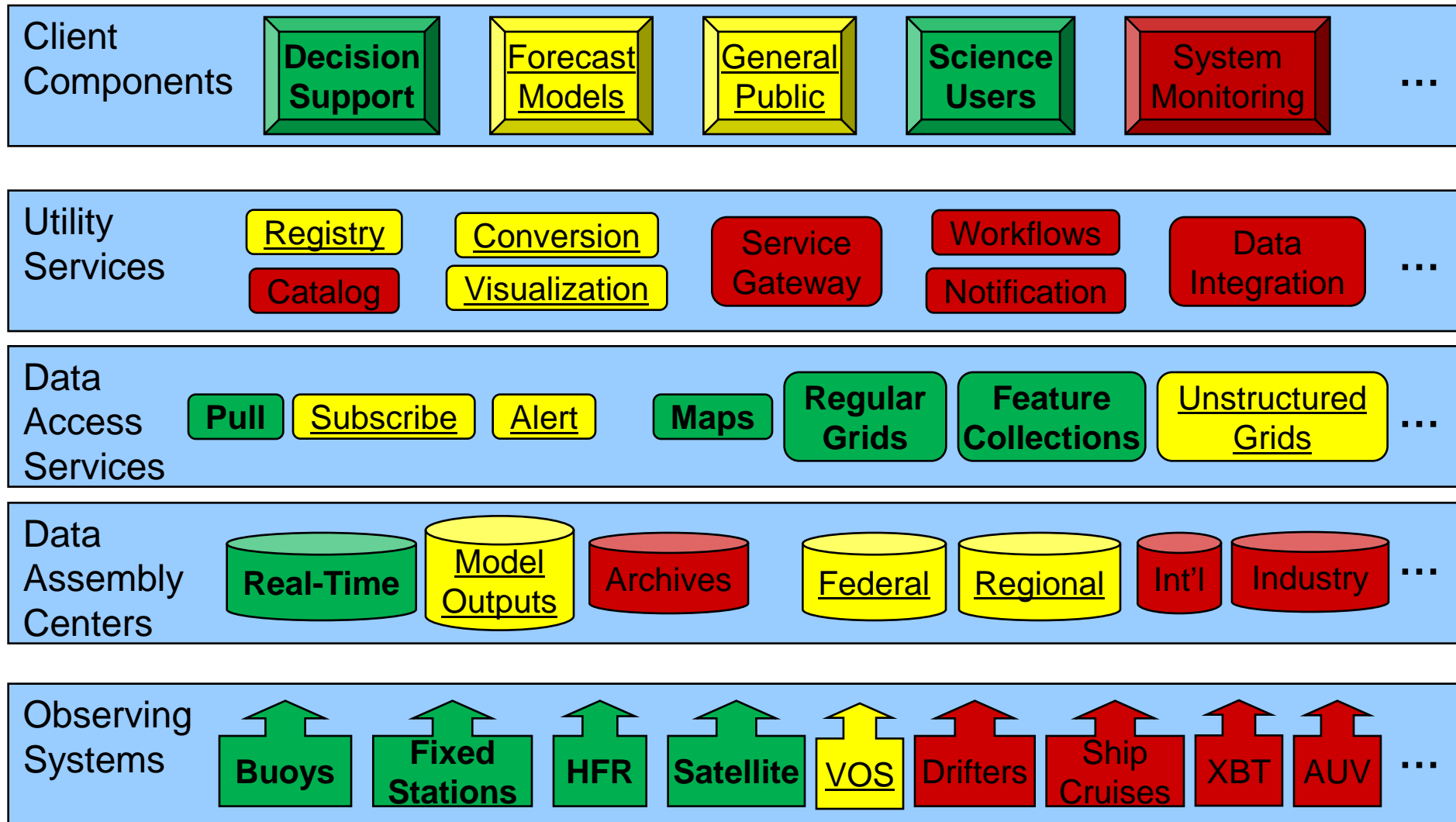
(International Organization for Standardization)





# Component Types Needed for IOOS

*Computational Viewpoint from Reference Model for Open Distributed Processing (RM-ODP)*



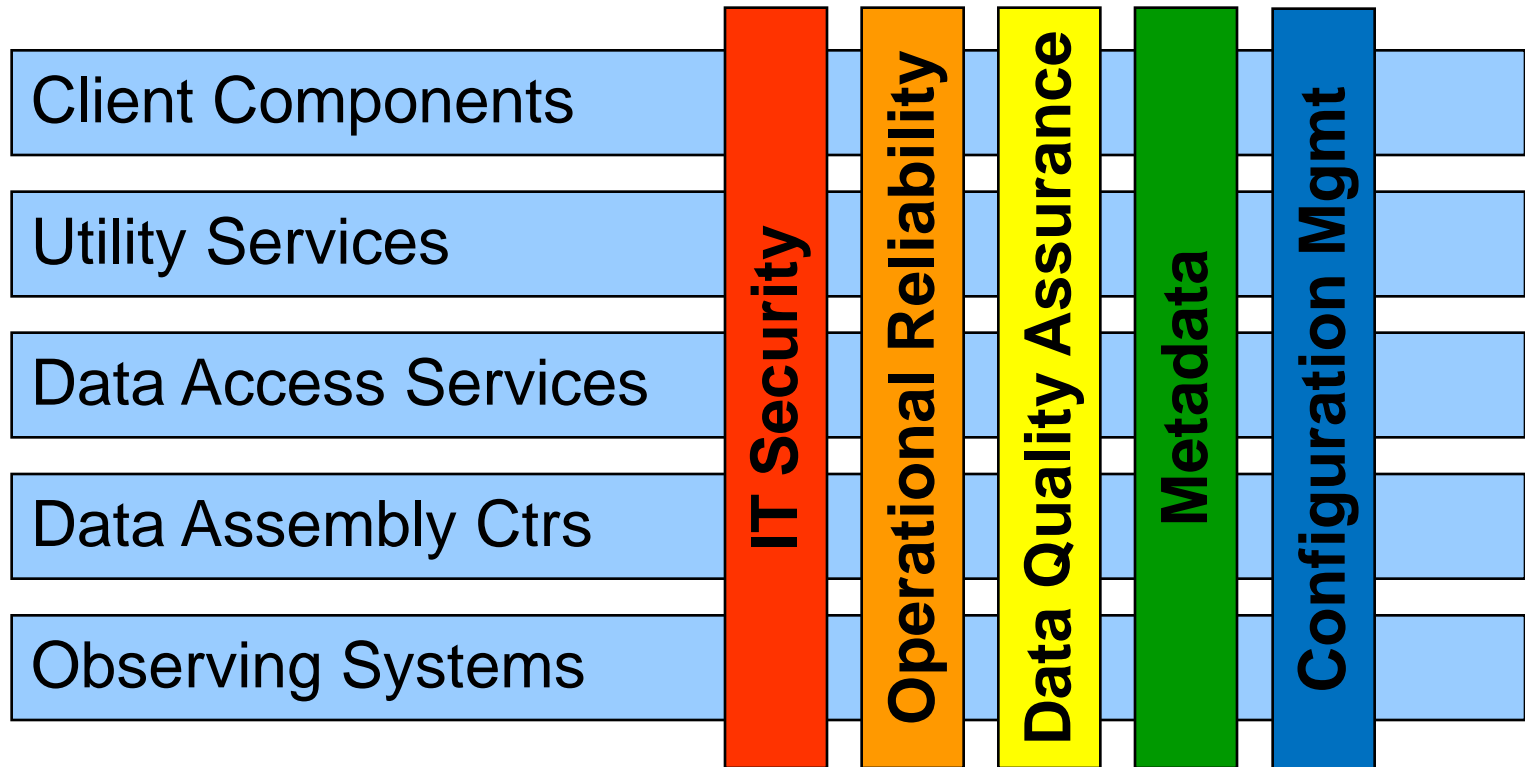
Legend:

Working  
examples

Starting/  
partial

Not yet  
addressed

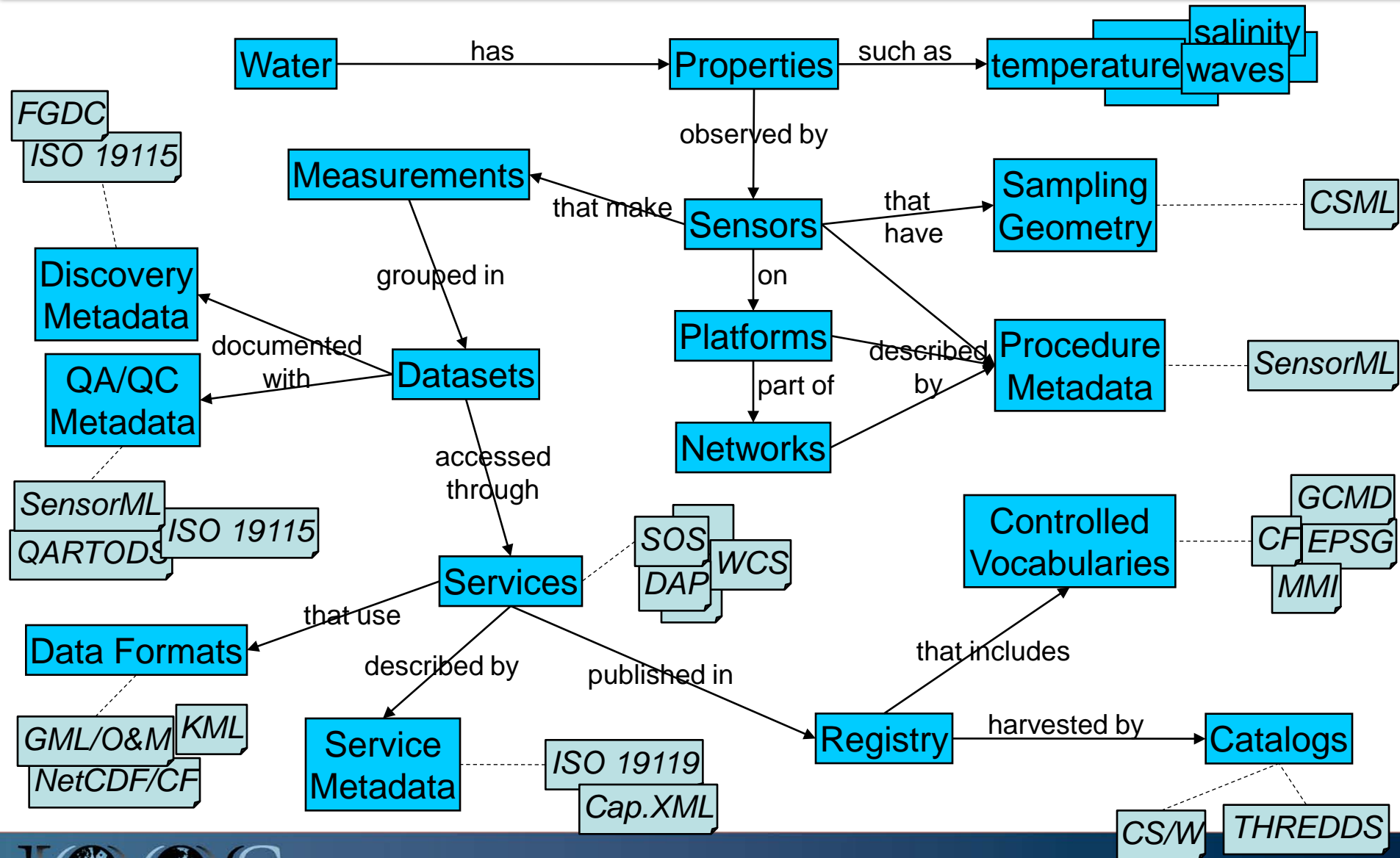
# Crosscutting Concerns



# Backup Slides

# IOOS Data and Metadata

*Information Viewpoint from Reference Model for Open Distributed Processing (RM-ODP)*



# IOOS Data and Metadata Types

*Information Viewpoint from Reference Model for Open Distributed Processing (RM-ODP)*

Service Metadata

(OWS Capabilities XML, ISO 19119)

Discovery Metadata

(FGDC, ISO 19115/19139)

Controlled Vocabularies

(CF, MMI, OGC, GCMD, URNs)

QA/QC Metadata

(QARTODS/Q20)

Sensor/Platform Metadata

(SensorML)

Data Encoding Conventions

(GML, KML, O&M, SWEC, CSML, NetCDF/CF)

Collection Types

(Time Series, Multi-Station Obs)

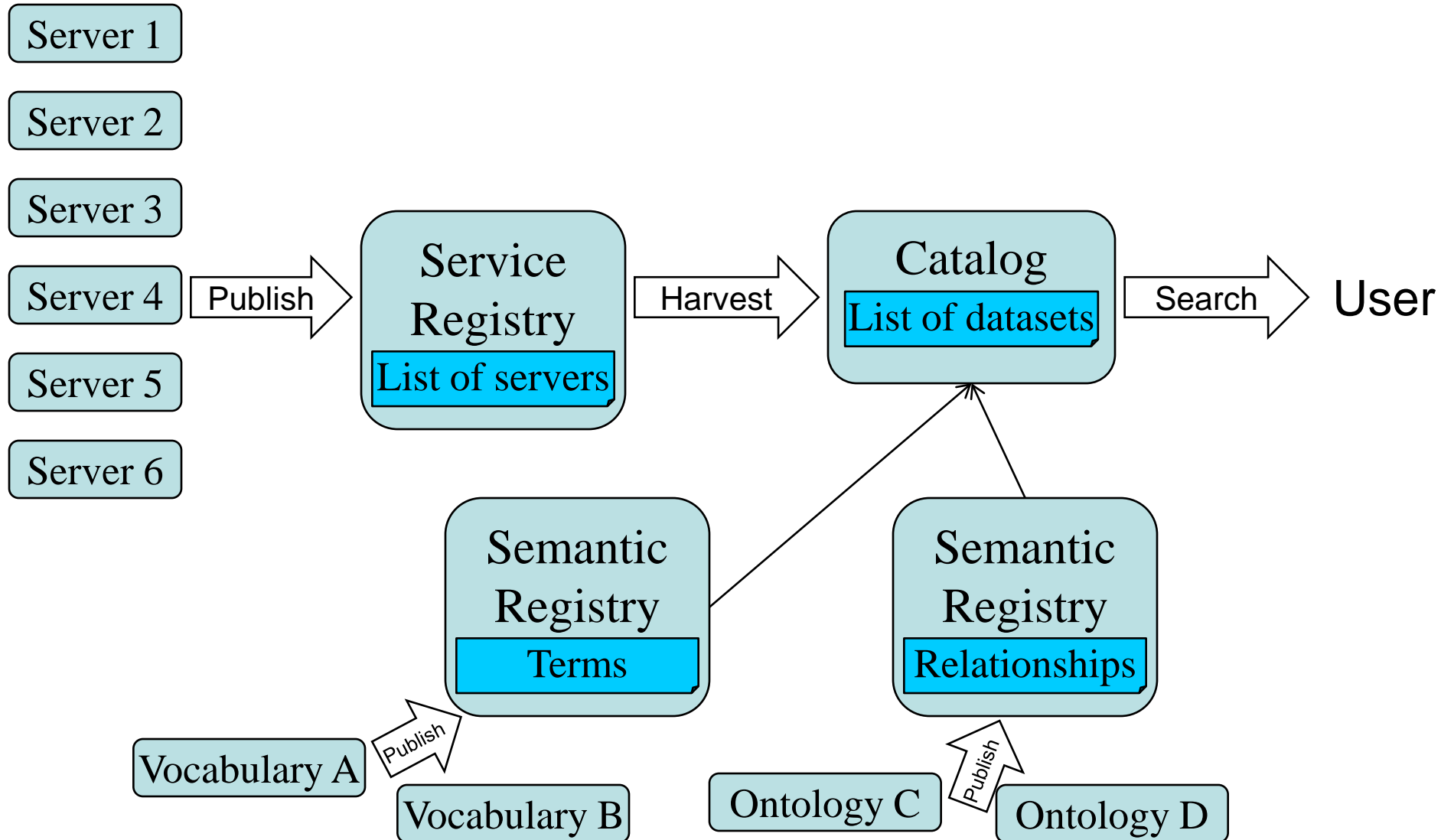
Sampling Feature Types

(Point, Profile, Trajectory, Reg Grid, Unstructured Grid)

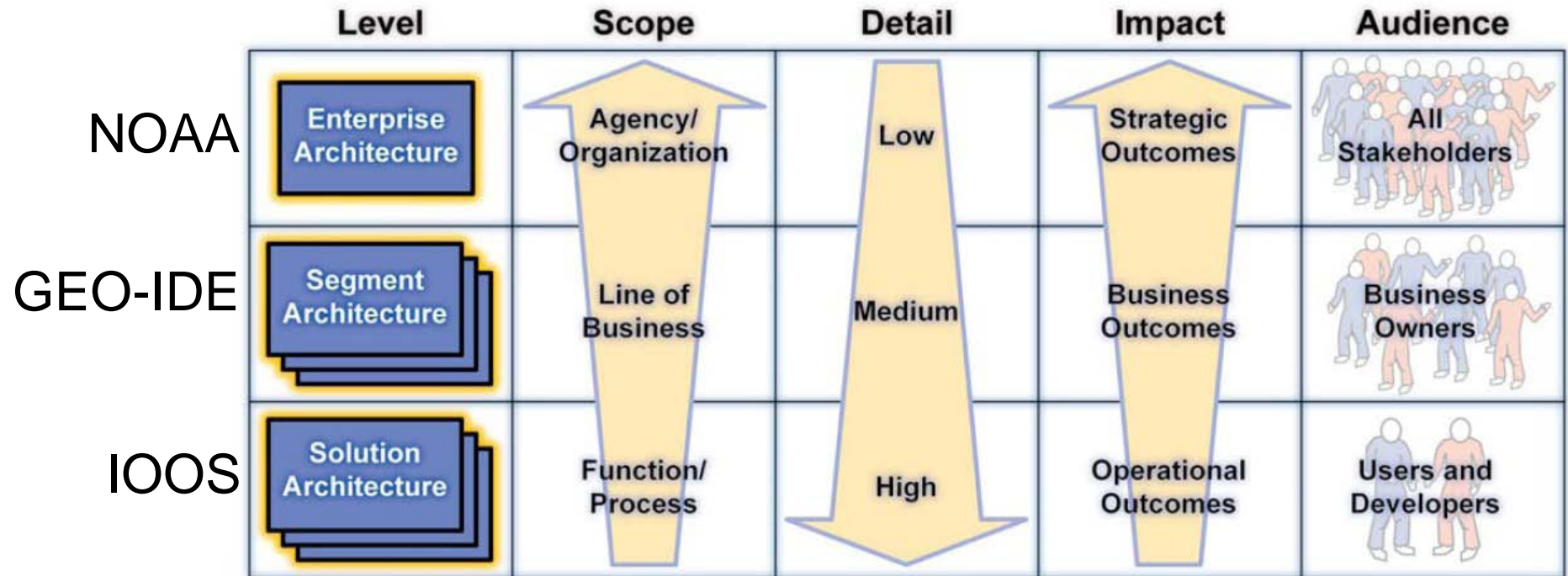
Ocean Properties

(Temperature, Salinity, Currents, Waves, Chlorophyll, ...)

# Registry and Catalog Concept



# NOAA EA, GEO-IDE and IOOS are complementary



Source: US OMB, Federal Enterprise Architecture Program Management Office, *FEA Practice Guidance* (2007), figure 1-3



# Strategic Direction and Drivers

- **Strategic direction:**
  - DIF Master Plan
  - NOAA IOOS Strategic Plan
- **NOAA IOOS Goals addressed by DIF:**
  - Improve access to high-quality, integrated data
  - Enhance data products and decision-support tools
  - Support NOAA and regional ocean observation capability
- **Other drivers**
  - NOAA is lead agency in Integrated Ocean Observing System
    - “Leadership” includes technical guidance
    - Must assess feasibility and value of IOOS
  - IOOS must link to other initiatives
    - GEO-IDE, GOOS, RCOOSs, GEOSS
    - Must harmonize services, data, technology

# Value of Integrated/Interoperable Data

## - "Performance Layer" of DIF EA

- **Improve access to high-quality, integrated data**
  - Standardized access services
  - Standardized data encodings
- **Enhance data products and decision-support tools**
  - Enable integration of data from multiple sources
  - Improve metadata and quality-control information
  - Meet functional requirements of identified customers
    - While not ruling out other customers
- **Support NOAA and regional ocean obs capability**
  - Coordinate standardization among NOAA providers
  - Fund and guide Regional Coastal Ocean Observing Systems

# Business Layer

- **Assess and recommend technologies and standards**
- **Coordinate technology choices with stakeholders**
  - Working groups
  - DMAC Standards Process
- **Reduce interoperability barriers**
  - Apply targeted funding
- **Assess technology and customer improvements**
  - Decide to expand/maintain/discontinue DIF
  - Determine path towards operational IOOS